Yacht Barnacle Inhibitor System

U.S. Patent Application of:

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Cross-Reference to Other Application

[0001] This application claims priority from 60/515,203 filed 10/28/2003, which is hereby incorporated by reference.

Background and Summary of the Invention

[0002] The present invention relates to systems and methods for controlling fouling, i.e. the growth of aquatic fauna (such as barnacles) on the wetted surfaces of ships and boats.

[0003] **Background: Barnacles and Fouling**

[0004] Barnacles, mussels, and algae have evolved to thrive underwater on the surfaces of rocks and in crevices. When these marine organisms grow on the hulls of marine vessels, the result is a significant increase in the surface roughness of the hulls known as fouling. Fouling creates drag on the vessels that reduces maneuverability and speed per unit of fuel used. Fouling also increases overall fuel costs and reduces operational time at sea during dry dock maintenance.

[0005] The traditional remedy has been a regular visit to the dry dock where barnacles and other organisms are scraped or sandblasted off the hull. An alternative used with small boats and special locations is treatment in situ, using underwater machines with divers and/or robotics.

[0006] The hull is then usually covered with a coat of antifouling paint designed to discourage future growth on the hull. To date, the most effective anti-fouling paints are based on organic compounds containing the metal tin, notably tributyltin (TBT). Applied to naval vessels, these organotins can protect the hull up to five years. TBT can be incorporated into self-polishing coatings, designed to wear away gradually as water flows by, releasing the barnacle-inhibiting compound at a constant rate.

[0007] The downside to TBT is that in waters contaminated with the antifouling agent, whelks were starting to show sex-changing disorders, and oysters developed abnormally thick shells. Concentrations of antifouling toxins have also been found in marine mammals. In 1988, as a result of these environmental concerns, Congress passed the Organotin Antifouling Paint Control Act (OAPCA) which forbids the use of TBT on vessels less than 25 meters long. This effectively banned the use of TBT on yachts and pleasure boats. Various foreign governments have also banned the use of organotin antifouling paint.

[0008] Because of these restrictions, copper compounds have re-emerged as the main active ingredients in antifouling coatings. Although these mixtures work well in the short term, the best formulations only last up to three years and do not match the five-year lifetime of the self-polishing TBT coating. And like TBT, copper-based antifouling agents work by poisoning the unwanted organisms. Therefore, there is fear that they too could cause environmental problems. (Such agents are generically referred to as "biocides," which gives some indication of their wide-ranging toxicity.) Copper, as well as other heavy metals commonly used as antifoulants, is listed as a toxic pollutant in section 307 of the Clean Water Act. Some copper-based antifouling paints also give off toxic fumes during application.

[0009] Extensive research is being done on anti-fouling paints which do not have such adverse environmental impacts, and many new compounds have been proposed. However, none have yet been shown to be as long-lasting and effective as traditional metal-ion compounds. There is, therefore, a great need for some way to inhibit growth of barnacles and similar organisms on boat hulls.

[0010] Fouling is not limited to macroscopic animals; fouling by bacteria can also be a problem. Bacterial fouling can accelerate corrosion, leading to pitting and even failure of metal alloy welds.

[0011] Fouling also occurs on stationary immersed structures, such as heat exchangers or cooling water intakes. However, the functional requirements of ship and boat hulls are quite different. Not only is drag reduction is very desirable, but hulls are exposed to very different conditions when underway and when docked or at anchor.

[0012] Especially when a vessel is docked, the hull will typically be in a nutrient-rich well-oxygenated environment which is ideal for growth, and where existing colonies of barnacles and the like provide a constant supply of larvae. When the vessel is underway, the flow of water can cause erosion of the antifouling paint.

[0013] Barnacles are not the only problem species. Freshwater hulls, especially in warm climates, may be colonized by mussels or other molluscidae.

[0014] **Yacht Barnacle Inhibitor System**

[0015] Anti-fouling treatments where the hull surface is exposed to bubbles of a gas which depletes oxygen. The presently preferred embodiment uses nitrogen, but other embodiments can use carbon dioxide, hydrogen, methane, or other gasses (especially those whose oxidation potential is neutral or reducing). In several disclosed embodiments, various techniques are used to restrict diffusion into the water volume which is immediately adjacent to the hull.

[0016] The disclosed inventions take advantage of a way in which the fouling problems of ships and boats (especially pleasure boats) differ from those of fixed structures: the periods when growth of fauna is fastest are the periods when resistance to water flow is least needed, i.e. when the boat is in a slip. The disclosed inventions, therefore, use gas bubble outlets to provide an oxygen-depleted environment around the hull, but only at times when the boat is docked (and preferably in a slip).

[0017] It has previously been discovered that oxygen depletion using bubbled nitrogen can slow the growth of bilge fauna. The disclosed embodiments apply this mechanism to the slightly less confined environment, namely the water which surrounds a boat in its slip.

[0018] In various embodiments, moving elements can be used to reduce wave-assisted diffusion of oxygenated water into the slip and/or to the hull surface.

[0019] The disclosed innovations, in various embodiments, provide one or more of at least the following advantages:

[0020] reduced fouling;

[0021] reduced reliance on anti-fouling paint;

[0022] reduced frequency of dry-dock scraping;

[0023] reduced frequency of in-water scraping;

[0024] increased fuel efficiency; and/or

[0025] increased top speed.

Brief Description of the Drawing

[0026] The disclosed inventions will be described with reference to the accompanying drawings, which show important sample embodiments of the invention and which are incorporated in the specification hereof by reference, wherein:

[0027] **Figure 1** shows a preferred embodiment utilizing "Y"-shaped bubble pipes.

[0028] **Figure 2** shows a configuration using a permeable line which runs along both sides of a keel.

[0029] **Figure 3** shows a configuration using an inflatable membrane.

[0030] **Figure 4** shows a hull-mounted embodiment.

[0031] **Figure 5** shows a slip embodiment.

[0032] **Figure 6** shows an alternative slip embodiment.

[0033] **Figure 7** shows an embodiment utilizing an "H"-shaped configuration of hose.

[0034] **Figure 8** shows an embodiment utilizing a bubble rig along both sides of the keel and centerboard of a sailboat.

[0035] **Figure 9** shows a testbed setup for monitoring growth reduction effects of oxygen-depletion bubbling.

[0036] **Figure 10** shows a plastic paint bucket placed for several months in the St. John's River next to a boat. This bucket was not surrounded by a fish tank bubbler.

[0037] **Figure 11** shows a plastic paint bucket placed for several months in the St. John's River next to a boat. This bucket was surrounded by a fish tank bubbler.

Detailed Description of the Preferred Embodiments

[0038] The numerous innovative teachings of the present application will be described with particular reference to the presently preferred embodiment (by way of example, and not of limitation).

[0039] Since nitrogen bubbling has been shown to deplete oxygen content in bilge water and thereby reduce mollusk growth, the present application teaches that nitrogen bubbled through a soft porous hose along the underside of a boat at a quiet slip where it spends most of the time, will inhibit barnacle growth.

[0040] A porous hose such as a lawn soaker hose can easily be placed on one or both sides of a boat while it is in a slip. This hose could be hooked over the transom and then tied to the bow such that it would lie near the keel. Typically, this is done on both sides of the boat to assure coverage. The porous portion only begins below the water line.

[0041] The hose material is preferably made of a fabric or soft rubber such that if the boat was started up by accident while the hose was below, the propeller would easily rip the hose apart without any damage to the propeller system.

[0042] The end of the bubbler hose connection is tied to a standard nitrogen bottle with a regulator to maintain a steady but very slow gas flow. (Alternatively, a nitrogen generator can be used instead of the bottle.)

[0043] In one class of embodiments, such a system is built into the fiberglass keel and requires a dockside connection to nitrogen.

[0044] Alternatively, the boat itself can include an air compressor and selective-flow tubing which produces nitrogen enhancement. (Such selectively permeable tubes are commonly available.)

[0045] **Figure 1** shows a preferred embodiment utilizing "Y"-shaped bubble pipes. Referring to Figure 1, "Y"-shaped bubble pipes **102** run along hull **106**. Bubble pipes 102 emit nitrogen around hull 106, thereby creating an oxygen-depleted environment around the hull.

[0046] **Figure 2** shows a configuration using a nitrogen-permeable line **204** that runs along both sides of keel **206**. Line 204 is connected directly to nitrogen source **202**. Nitrogen is pumped from source 202 into line 204. Only the portion of line 204 that is submerged in water is nitrogen-permeable. Once nitrogen is pumped from source 202 into line 204, nitrogen will be emitted through the nitrogen-permeable portion of the line 204, thereby creating an oxygen-depleted environment around hull 106.

[0047] **Figure 3** shows a configuration using an inflatable membrane embodiment of the present invention. Referring to Figure 3, nitrogen source 202 is connected to a nitrogen-permeable membrane **302**. Once floats **304** are inflated, membrane 302 surrounds hull 106 and emits nitrogen into water **306** that is contained around the hull, thereby creating an oxygen-depleted environment around hull 106.

[0048] **Figure 4** shows a hull-mounted embodiment of the present invention. Referring to Figure 4, nitrogen pumped from source 202 is emitted into the area surrounding hull 106 via hoses **402** that are attached to hull 106. Once nitrogen is released from hoses 402, an oxygen-depleted environment is created around hull 106.

[0049] **Figure 5** shows a slip embodiment of the present invention. Referring to Figure 5, the slip may be made of plastic or fiberglass and can utilize walls **504** or bottom blanket **506**. The slip configuration can also utilize a back gate **508**. The slip creates a contained area **502** around hull 106. The slip prevents water motion through the slip, thereby reducing the amount of nitrogen required to create an oxygen-depleted environment around hull 106.

[0050] **Figure 6** shows an alternative slip embodiment utilizing an onshore or on-dock treatment system for slip water in a semi-contained slip. Referring to Figure 6, semi-contained slip water **602** is created around hull 106 by the use of back gate 508. Slip water 602 is passed though a water conditioning system **600** to deplete the oxygen content. A return water conditioning line **604** is used to return the conditioned water either to a hull dispersion system or directly to the slip water, thereby creating an oxygen-depleted environment around hull 106.

[0051] **Figure 7** shows an embodiment utilizing an "H"-shaped net. Referring to Figure 7, an "H"-shaped net **702** is placed along hull 106. Net 702 emits nitrogen along hull 106, thereby creating an oxygen-depleted environment around the hull.

[0052] **Figure 8** shows an embodiment utilizing a bubble rig along both sides of the keel and centerboard. Referring to Figure 8, two bubble rigs **802** are connected at bow **808** and stern **810**. The bubble rigs are placed along both sides of keel **804** and center board **806**. Bubble rigs 802 may be placed in parallel with one another or may be crisscrossed. Bubble rigs 802 emit nitrogen along hull 106, thereby creating an oxygen-depleted environment around the hull.

[0053] **Figure 9** shows a testbed setup for monitoring growth reduction effects of oxygen-depletion bubbling. Referring to Figure 9, **902** and **904** are 5 gallon plastic paint buckets that have been cut in half and then weighted to sit in marine water **908**. An aquarium air stone **906** emitting nitrogen gas from nitrogen source 202 has been placed at the bottom of bucket 904.

[0054] **Figures 10** and **11** show plastic paint buckets that were placed for several months in the St. John's River next to a boat. The buckets were held into the water with a weight from the bottom. The bucket in Fig. 11 was surrounded by a fish tank bubbler while the bucket in Fig. 10 was not. As seen in the figures, the amount of growth on the bucket surrounded by the fish tank bubbler in Fig. 11 is noticeably less than the amount of growth on the bucket that was not near the bubbler.

[0055] **Modifications and Variations**

[0056] As will be recognized by those skilled in the art, the innovative concepts described in the present application can be modified and varied over a tremendous range of applications, and accordingly the scope of patented subject matter is not limited by any of the specific exemplary teachings given.

[0057] A particular advantage of using a gate to reduce water diffusion into the slip is that some sort of gas supply will necessarily be present anyway.

[0058] Note also that at least two Y configurations are possible, one avoiding the prow and one avoiding the props.

[0059] Embodiments with demountable rigs mounted to the rig can be emplaced by dropping the hoses or tubing in from the bow, and having two people walk back the pair of endpoints to tie them to rails abaft.

[0060] Optionally, the hoses or tubing can be weighted, so that they will hang centrally even when inflated.

[0061] Various adaptations can be made to conform to different wetted hull shapes. For example, on a sailboat, two bubbler tubing networks can be used, e.g. one fore and one aft of the keel. (Alternatively, one can be located to port and one to starboard of the keel.) On a catamaran four demountable tubing networks can be used.

[0062] Optionally, weighted lines with bubbler tubing can be located on the bottom of a slip when deflated. In this embodiment, the lifting action of the bubbles will help to clear any silt when the air pump is started up.

[0063] In one contemplated embodiment, two inflatable floats on either side of the boat would carry a "sling" (a sheet of durable material) between them, with imbedded bubblers in it. The floats would be inflated after the boat entered the slip - this would bring the sling to wrap around the hull and provide for bubbling in close proximity to the hull. By confining the volume of (oxygen-depleted) water next to the hull, the required volume of nitrogen (or other gas) can be reduced. When the boat is going to be used, the floats would be filled with water, and the weighted tubing rig sinks back to the bottom.

[0064] Depending on the material and cut of the sling, it may also be able to reduce incursion by barnacle larvae. The sheet itself can also be impregnated with fauna repellents if desired.

[0065] Freshwater boats, especially in warmer waters, have similar problems. The species and varieties which colonize the wetted surfaces tend to be different, but the ecology of growth substrates in a high-nutrient aquatic environment is very similar. In alternative embodiments, the disclosed bubbler and/or deoxygenating systems can be used in freshwater slips, on freshwater boats, and on boats which are used both in freshwater and in brackish or salt water.

[0066] Encrustation is not quite as pressing an issue in maritime cargo and naval vessels, where biocide paints are still prevalent, but fouling is still an important issue. Fuel economy is an important cost factor in maritime shipping, and top speed is very important in many naval vessels. The size of cargo and naval vessels makes use of a sling less practical, but bubbler hoses, slung under the hull at anchor, are contemplated to be useful on such ships too. With most large ships, the ship normally rides at anchor but does not enter an enclosed slip. Thus, large ships (over 250 tons or over 250 feet overall) are contemplated as an alternative but less preferred embodiment.

[0067] One type of oceangoing ship already has gas outlets in the hull. Some icebreakers have underwater gas outlets in the wetted part of the reinforced bow. Gas is pumped through these outlets during icebreaking operations. It is believed that air under the leading edge of the ice weakens it. The air injection may also help the ship to accelerate rapidly when ramming is desired. However, barnacle fouling is not normally a problem with icebreakers!

[0068] Optionally, the slip is made with a fiberglass or other plastic molded shell that stays under the hull or forms the slip, and this shell can carry the fluid network for bubble system within it. This could also remove some of the wave action that would shift the de-oxygenated water away from the hull of the boat.

[0069] Optionally, a membrane can be stretched between two rigid supports and would lay on the bottom until the boat came into the dock. The membrane then is lifted off the bottom (e.g. by pumping air into buoyancy sacks) so that it meets the bottom of the boat. The inside is made permeable so that the bubbles would remove the oxygen in the water between the membrane and the hull.

[0070] In one option, a recirculation system is used, so that the water is deoxygenated inside of a water treatment package remote from the slip, and then pumped back into the area around the hull.

[0071] In another option, a recirculation system is used, but the water is deoxygenated in a water treatment package inside the hull.

[0072] Nitrogen is preferred because of it is environmentally safety. However, other gases can optionally be used instead. Preferably the gas used will have an oxidation potential which is neutral or reducing. For example, one possibility is carbon dioxide. Another possibility is hydrogen, e.g. electrolytically generated from seawater. Analogous gases can be used, including even engine exhaust gases (in cases where an engine, such as a generator, will be running while the boat is docked).

[0073] For a completely closed-circulation slip, both sides are also preferably closed off, e.g. other inflatable curtains.

[0074] The props have a good deal of encrustation as well depending on the polish and material.

[0075] Some boats leave the air conditioning on all the time when at dock, just to keep the moisture out of the interior decor. These are water-cooled systems and, therefore, have a water draw in the hull. This could be a custom membrane with cutouts for this. Same problem with the heads needing water - they are not supposed to dump the head at dock (goes instead to an inboard holding tank) but, this is not always followed.

[0076] In one alternative class of embodiments, the oxygen content of the water near the hull is monitored to make sure that it does not go too low since decomposition of marine fauna in anaerobic water can produce a very strong stench.

[0077] None of the description in the present application should be read as implying that any particular element, step, or function is an essential element which must be included in the claim scope: THE SCOPE OF PATENTED SUBJECT MATTER IS DEFINED ONLY BY THE ALLOWED CLAIMS. Moreover, none of these claims are intended to invoke paragraph six of 35 USC section 112 unless the exact words "means for" are followed by a participle. Moreover, the claims filed with this application are intended to be as comprehensive as possible: EVERY novel and nonobvious disclosed invention is intended to be covered, and NO subject matter is being intentionally abandoned, disclaimed, or dedicated.